Systems programming
3 – SysML

MEEC LEEC MEAer LEAer MEIC-A
João Nuno Silva

TÉCNICO LISBOA

Bibliography

- Books
  - Practical Guide to SysML Systems Modeling Language - Sanford Friedenthal
    - Chapters 2, 3
  - SysML Distilled - Lenny Delligatti
    - Chapter 1, 2
- Tutorials
  - OMG Systems Modelling Language (OMG SysMLTM) Tutorial September, 2009
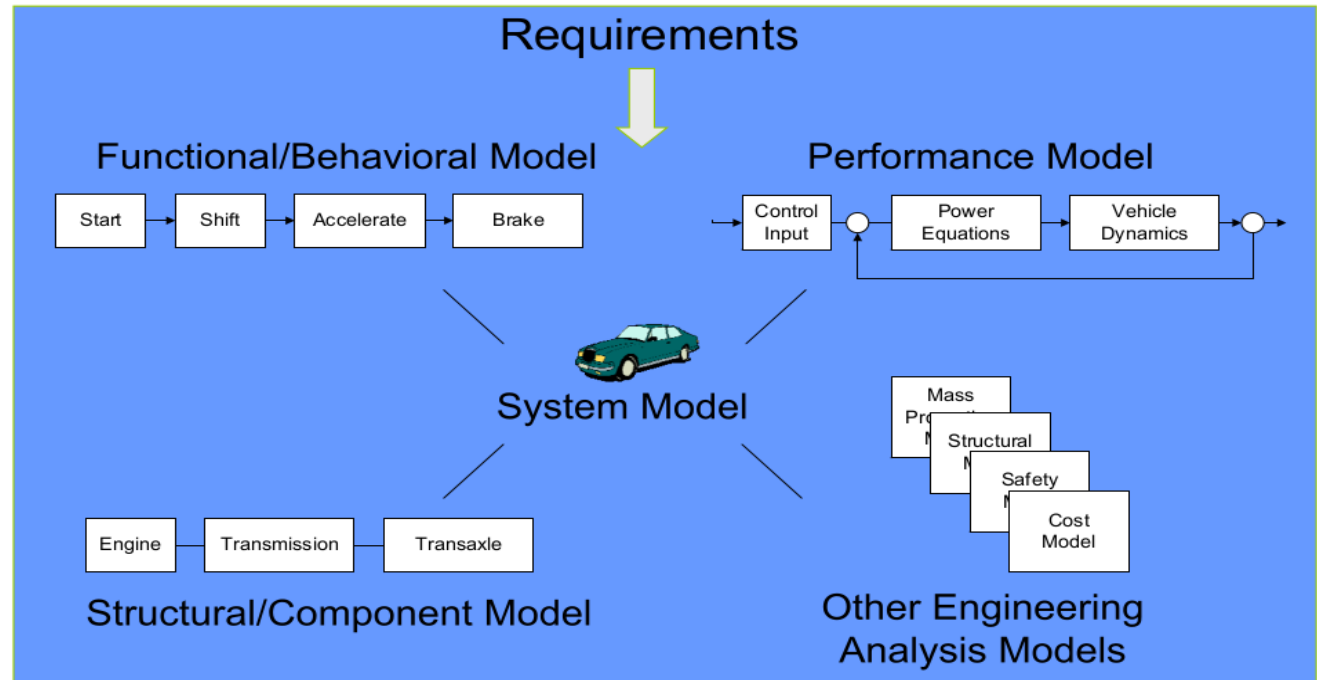
System description

How to describe system?

- Integrated models must address multiple aspects of a System

Model Based Systems Engineering

- Shared understanding of system requirements and design
  - Validation of requirements
  - Common basis for analysis and design
  - Facilitates identification of risks

- Assists in managing complex system development
  - Separation of concerns via multiple views of integrated model
  - Supports traceability through hierarchical system models
  - Facilitates impact analysis of requirements and design changes
  - Supports incremental development & evolutionary acquisition

Model Based Systems Engineering

- Improved design quality
  - Reduced errors and ambiguity
  - More complete representation

- Supports early and on-going verification & validation to reduce risk

- Provides value through life cycle (e.g., training)

- Enhances knowledge capture

Model Based Systems Engineering

- Primary artifact is system model,
  - An integrated, coherent, and consistent view
  - Created using dedicated systems modelling tools

- Other artifacts are secondary
  - Automatically generated from the system model
  - Using the same modelling tool

- The system model serves
  - Central repository for design decisions

- Each design decision is captured as
  - A model element (or a relationship between elements)
  - In a single place within the system model.

Model Based Systems Engineering

- Modeling Languages (grammar)
  - a semiformal language that defines
    - the kinds of elements you're allowed to put into your model,
    - the allowable relationships between them,
    - And the set of notations you can use to display the elements and relationships on diagrams

- Modeling Methods
  - set of design tasks that a modelling team performs to create a system model
  - Design tasks that ensures that everyone on the team is building the system model consistently

Modelling Tools

- Designed to comply with the rules of modelling languages

- Enables the construction well-formed models
  - Based in those languages

- Modification an element on a diagram within a modelling tool,
  - modifying the element itself in the underlying model.
  - Instantaneously updated all the other diagrams with that element

- Different from from diagramming tools (Visio)
  - Diagramming tool
    - Creation of diagrams—shapes on a page.
    - No model underlying those diagrams with automated consistency

SysML

SysML

- A graphical modelling language

- Supports
  - the specification, analysis, design, verification, validation of systems
  - Description of hardware, software, data, personnel, procedures, and facilities

- Supports model and data interchange
  - via XML Metadata Interchange

SysML

- Is a visual modelling language that provides
  - Semantics = meaning
  - Notation = representation of meaning
- Is not a methodology or a tool
  - SysML is methodology and tool independent
- Based in UML
  - Includes some types of models
  - Extends with new types of models

SysML Diagrams

- Structure Diagrams
  - Block definition diagram (BDD)
  - Internal block diagram (IBD)
  - Parametric diagram
  - Package diagram
- Behavior Diagrams
  - Use case diagram
  - Activity diagram
  - Sequence diagram
  - State machine diagram
- Requirements diagram
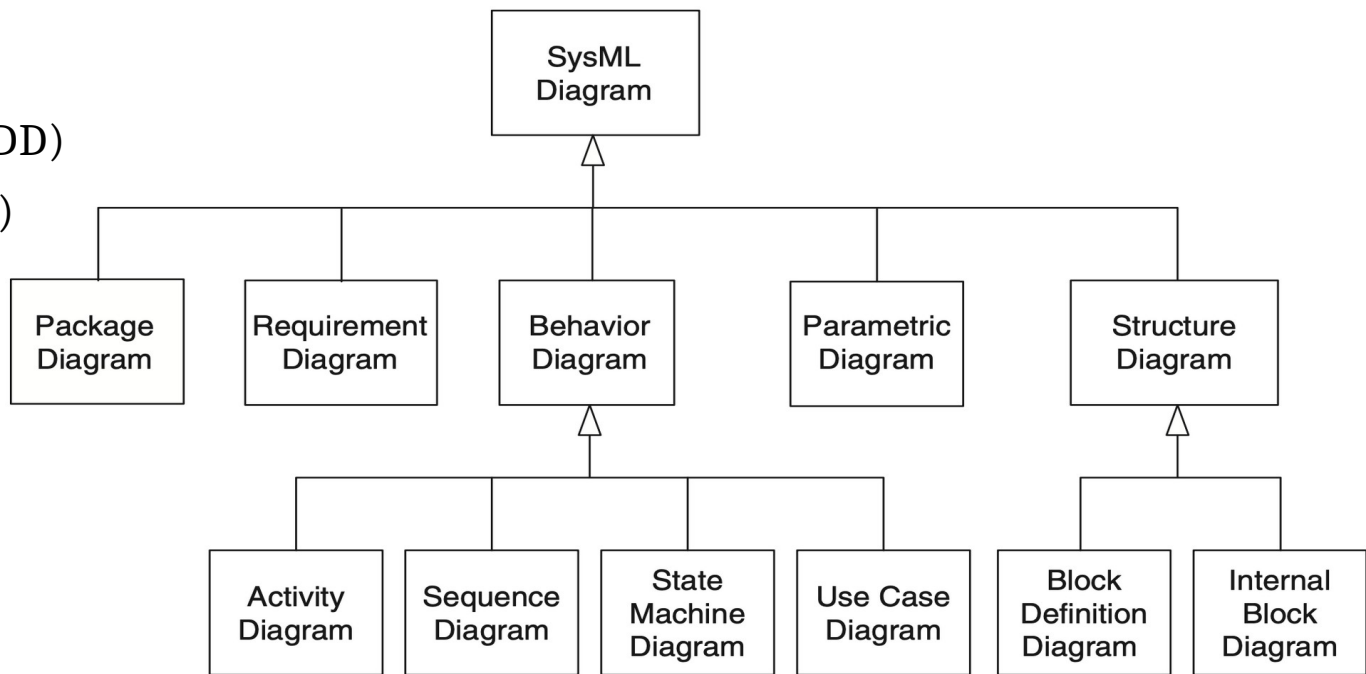
General Diagram Concepts

- Each diagram has
  - Frame
  - Header.
  - Contents area / "canvas"

- Header contains
  - Diagram kind
  - Model element type
  - Model element name
  - Diagram name

- A diagram of the model is never the model itself
  - it is merely one view of the model

- Diagrams should not attempt to convey every detail
  - the diagram would become unreadable

- If a feature doesn't exist in a diagram
  - it may be shown on another diagram or on no diagram at all.

SysML-Lite diagrams

SysML-Lite Diagrams

- Simplification of SysML - Only 6 types of diagrams

- Block definition diagram
  - Represents the system hierarchy
- Internal block diagram
  - Represents the system interconnection
- Parametric diagram
  - Captures the relationship among system properties to support engineering analysis

- Package diagram
  - Captures the model organization
- Requirement diagram
  - Captures text-based requirements
- Activity diagram
  - Represent the behavior of the system and its components

Package diagram

- Displays the way a model is organized
  - package containment hierarchy.

- May show

  - Models that each packages contain
  - Dependencies between packages
    - and their contained model elements.

- Represents the model organization
 - Not the system organization
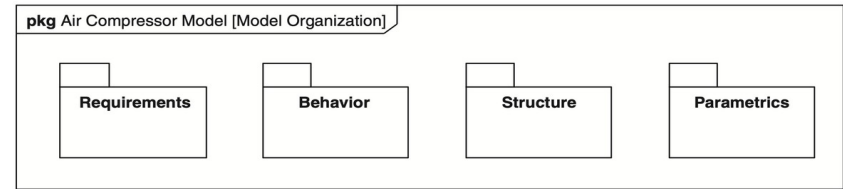
Requirement diagram

- Displays
  - Text-based requirements
  - the relationships between requirements (contain- ment, derive requirement, and copy),
  - relationships between requirements and the other model elements
    - that satisfy, verify, and refine them.
- Objects in these models represents a text based requirement
  - Includes id and text properties
  - Can add user defined properties such as verification method
  - Can add user defined requirements categories
    - (e.g., functional, interface, performance)
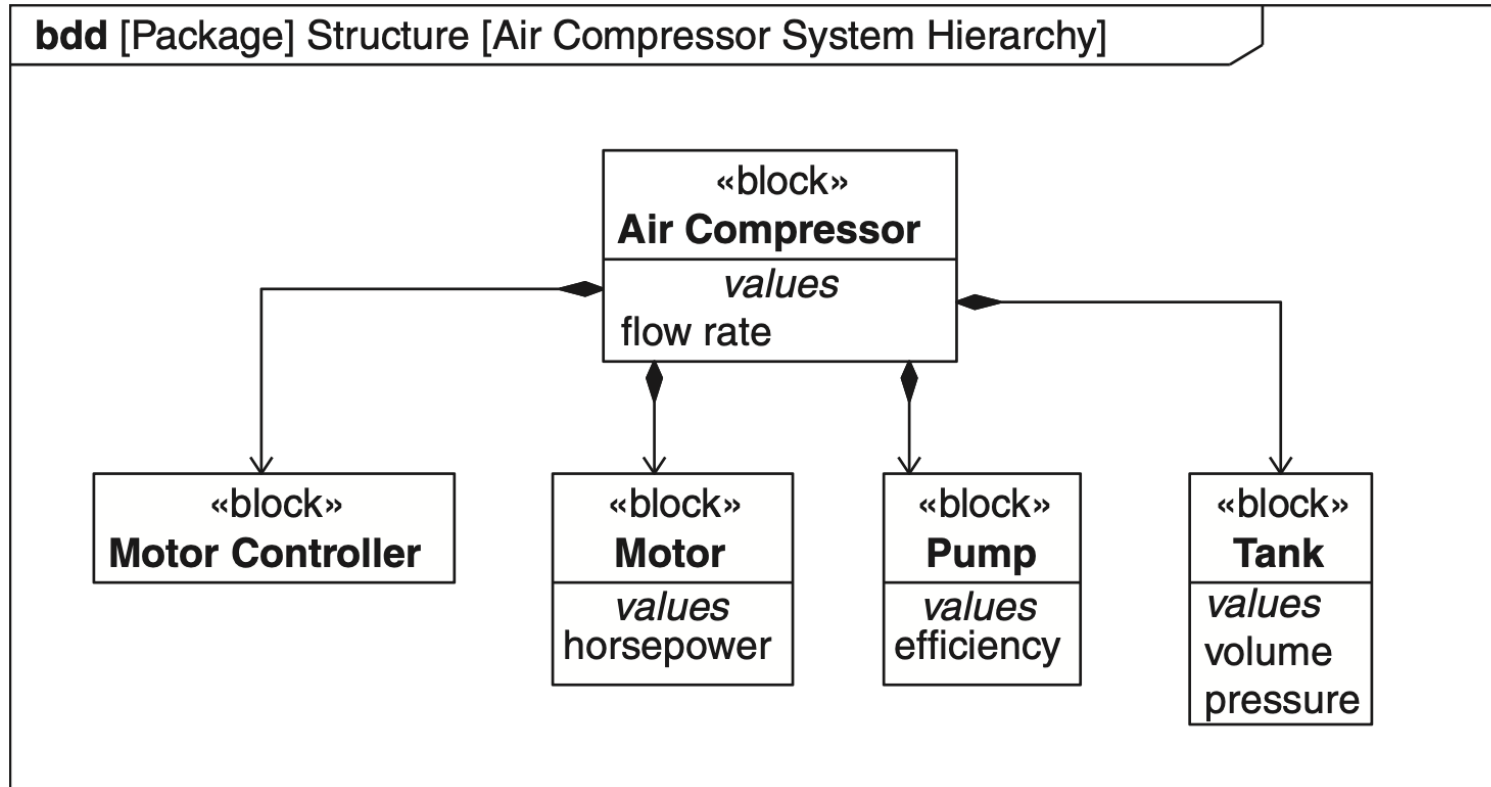- Requirements hierarchy can be defined

Requirement diagram
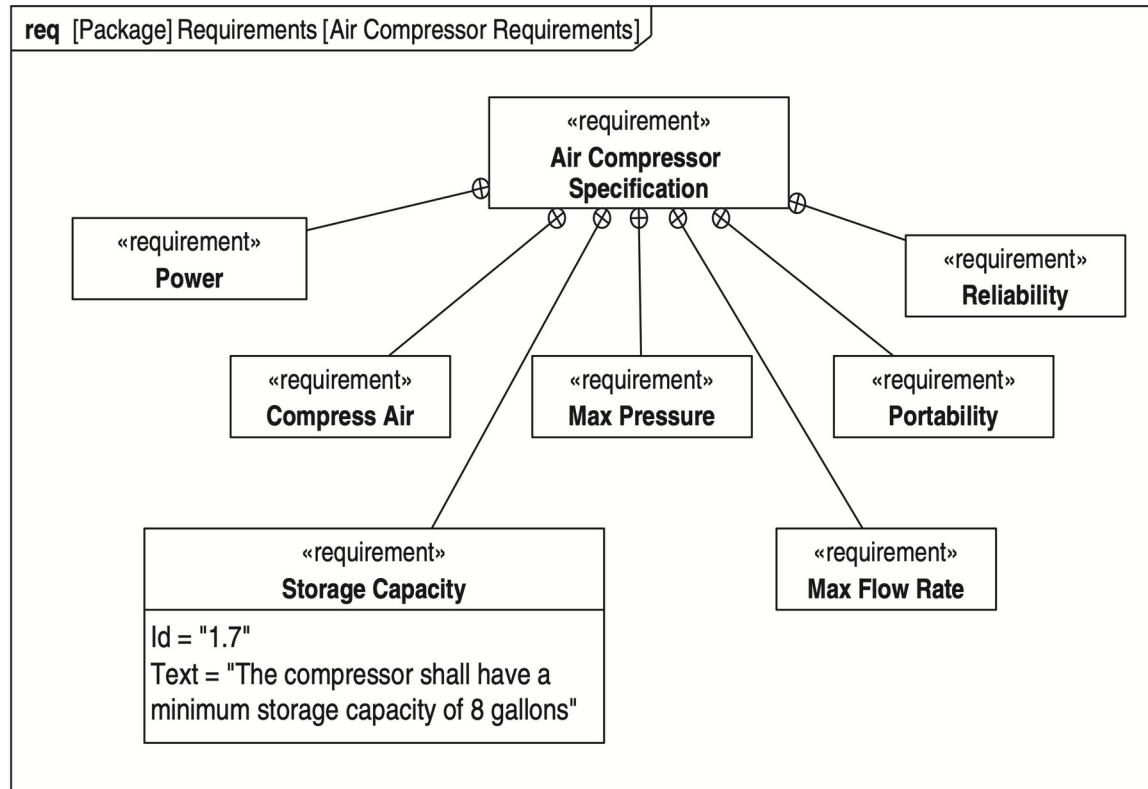
Requirement diagram
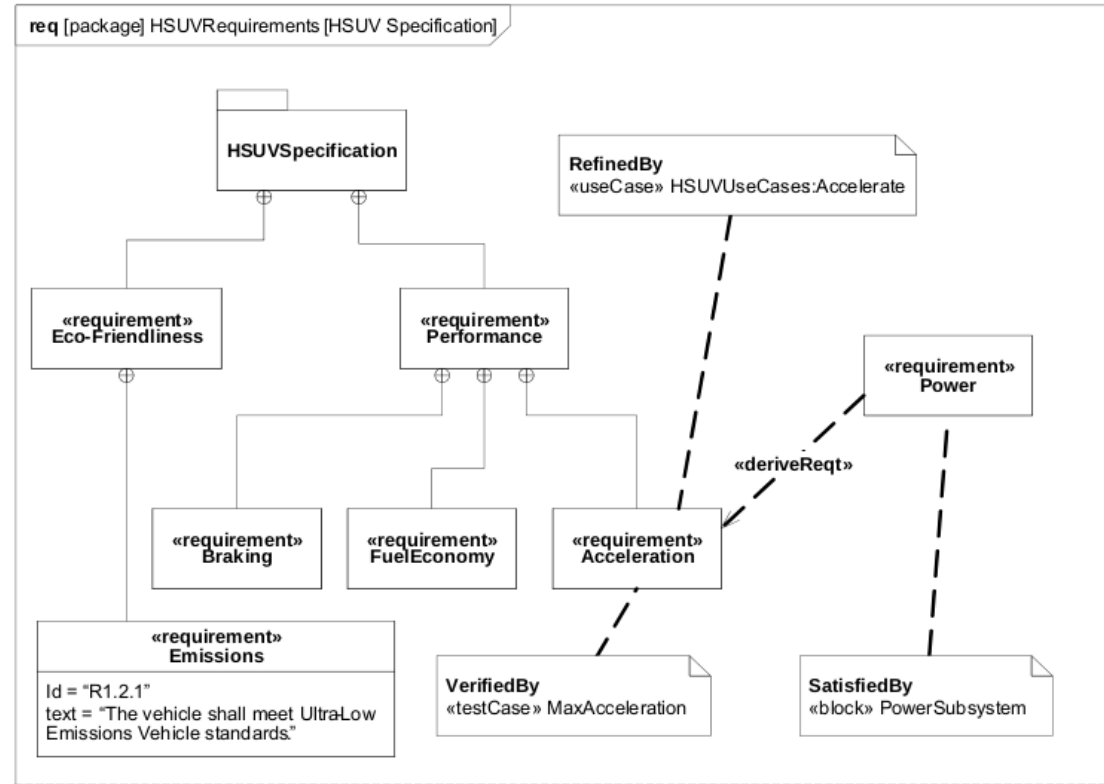
Block Definition diagrams

- Express the types of structures that can exist
  - internally within a system
  - externally in a system's environment.
  - Blocks
    - Entities (subsystems, components, ...) within the system or external environment.
  - Actors
    - someone or something that has an external inter- face with your system
- Block definition diagram describes the relationship among blocks
  - composition, association, specialization
  - Allow hierarchies and design to abstractions providing extensibility
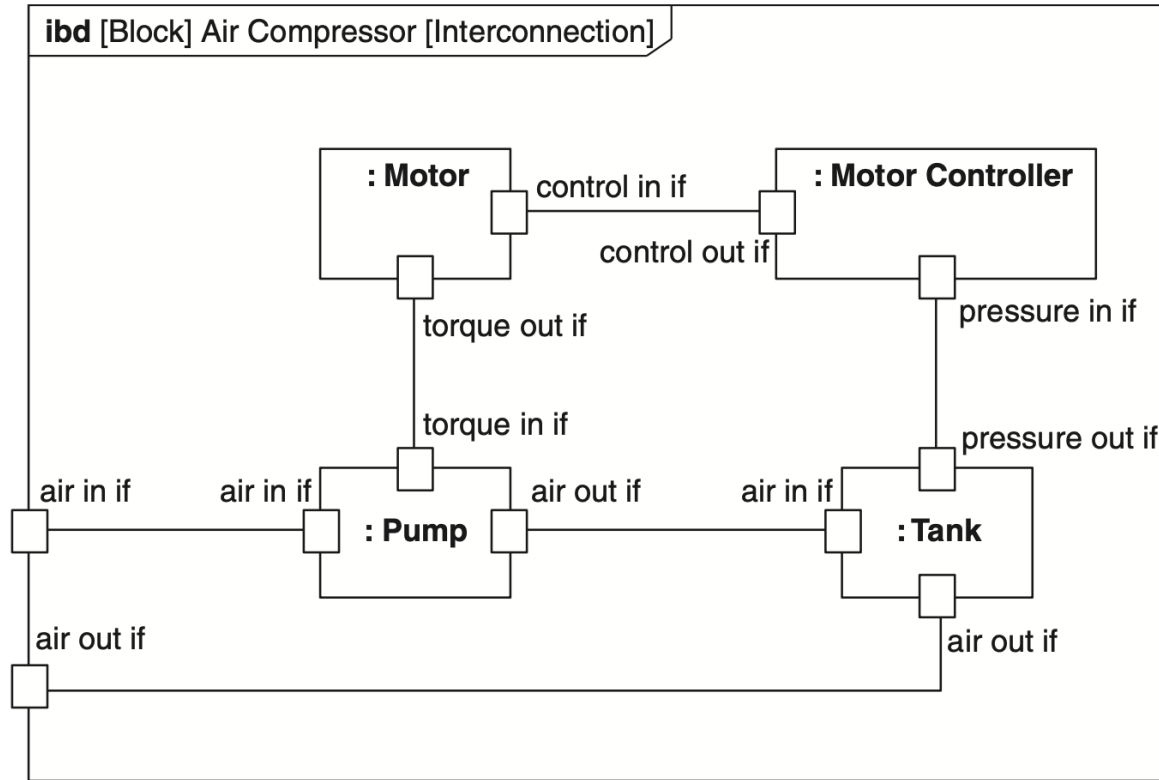- Do not represent how/what blocks interact

Block Definition diagrams

bdd [Package] Structure [Air Compressor System Hierarchy]

«block»
Air Compressor

values
flow rate

«block»
Motor Controller

«block»
Motor

values
horsepower

«block»
Pump

values
efficiency

«block»
Tank

values
volume
pressure

Internal Block Diagram

- Describing internal structure of each Block
- Block Definition Diagram (BDD)
  - Black box
- Internal Block Diagram
  - white-box
- Complements the information on a Block Definition Diagram
  - Presents connections between blocks
  - Describes the services that interact to one another
  - Defines types of matter, energy, and data that can flow among them across their connections.

Internal Block Diagram

ibd [Block] Air Compressor [Interconnection]

: Motor — control in if — : Motor Controller
control out if
torque out if
pressure in if
torque in if
pressure out if
air in if   air in if   : Pump   air out if   air in if   : Tank
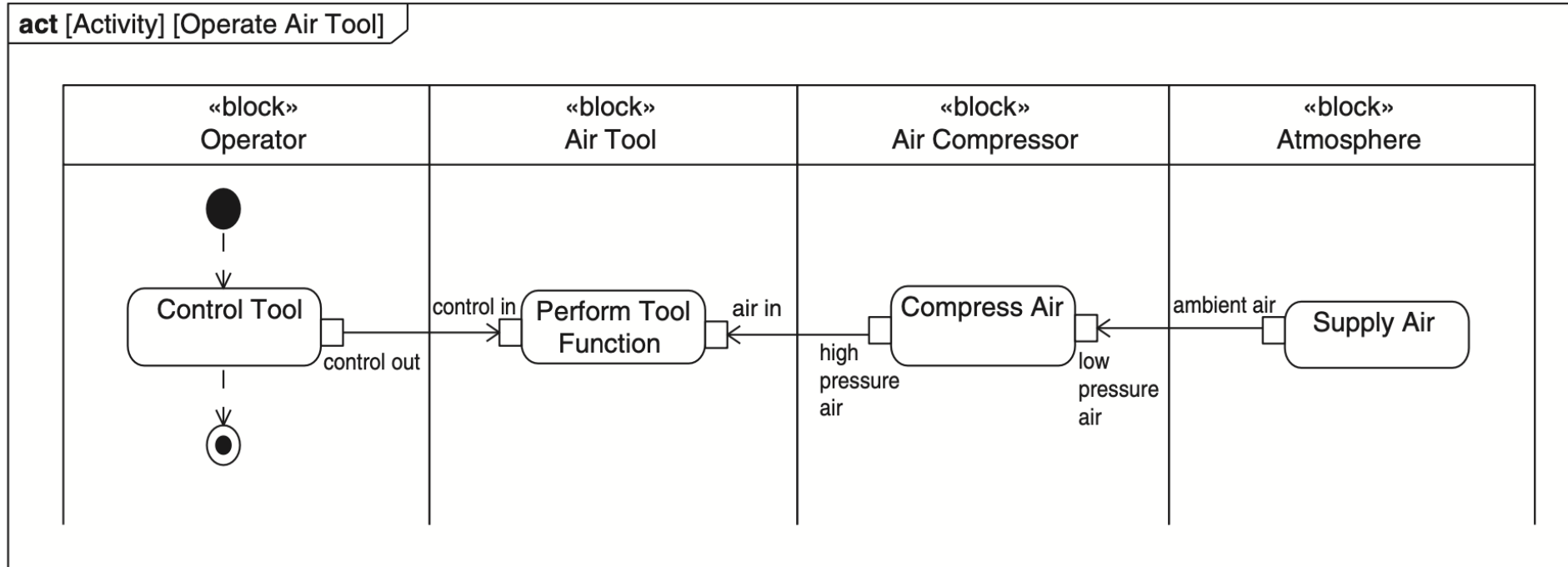air out if
air out if

Activity diagram

- Express system's dynamic behavior
  - Focus on the flow of matter, energy, and data among a set of actions, whether sequential or concurrent.

- Each diagram represents one activity in the system
  - specifies transformation of inputs to outputs
  - through a controlled sequence of actions

- Express the order in which actions are performed,
  - they can optionally express which structure performs each action.
  - But do not offer any mechanisms to express which structure invokes each action

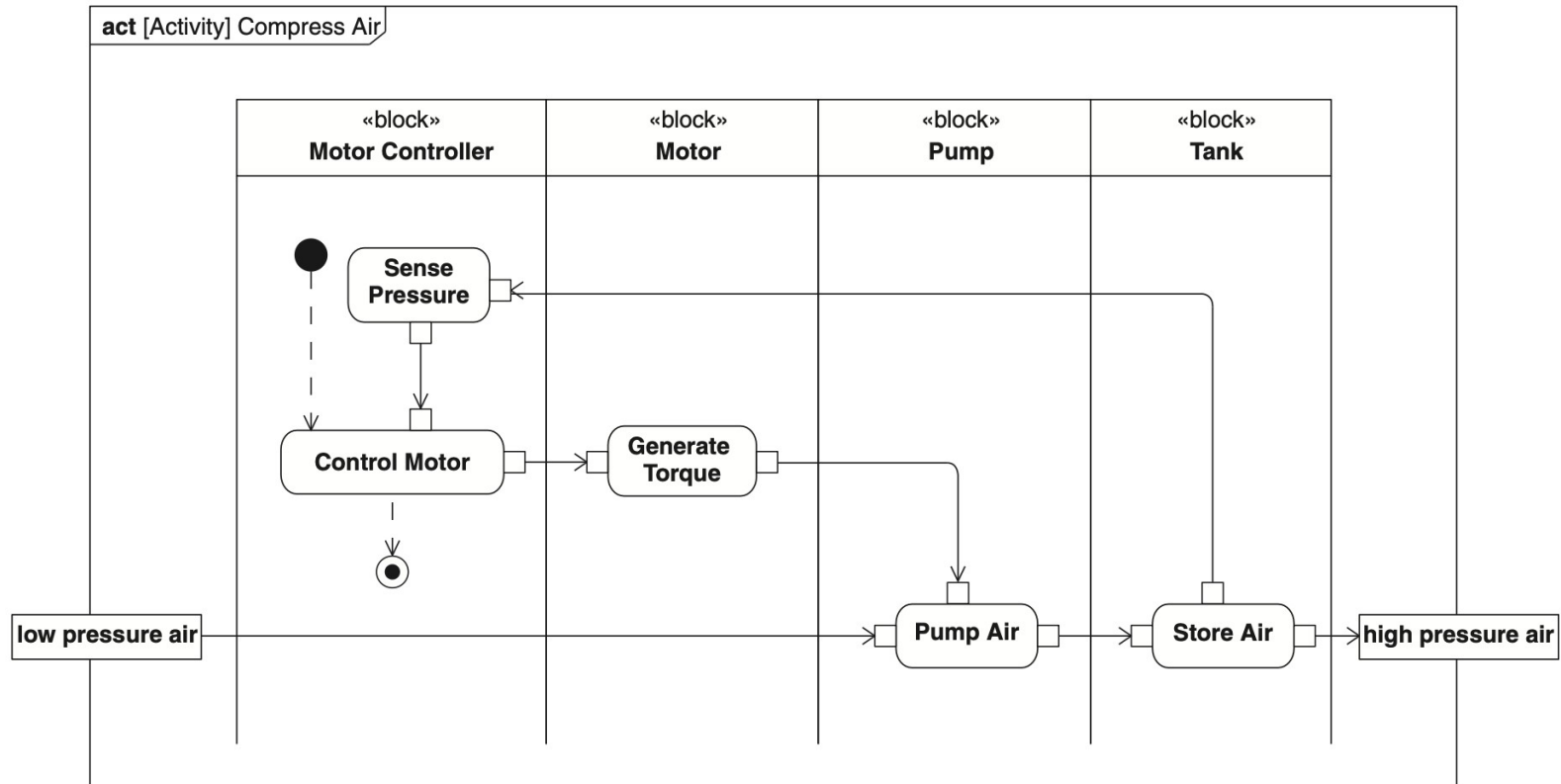- Allows assignment of actions responsibility to specific structures within a system.

Activity diagram

- Can send signal actions and accept event actions

- Allows model asynchronous communication

- Allows wait time actions

  - to model behaviors that occur periodically

 - begin at particular moments in time.

Activity diagram

act [Activity] [Operate Air Tool]

| «block» Operator | «block» Air Tool | «block» Air Compressor | «block» Atmosphere |

Control Tool → control in → Perform Tool Function ← air in ← Compress Air ← ambient air ← Supply Air

control out, high pressure air, low pressure air

Activity diagram

Parametric diagram

- Expresses constraints
  - generally, equations and inequalities
  - determine the values that are valid in a system that's operating nominally.
- Can express constraints/equations between value properties
  - Provides support for engineering analysis (e.g., performance, reliability)
  - Facilitates identification of critical performance properties
- Constraint block captures equations
  - Expression language can be formal (e.g., MathML, OCL) or informal
  - Computational engine is provided by applicable analysis tool and not by SysML
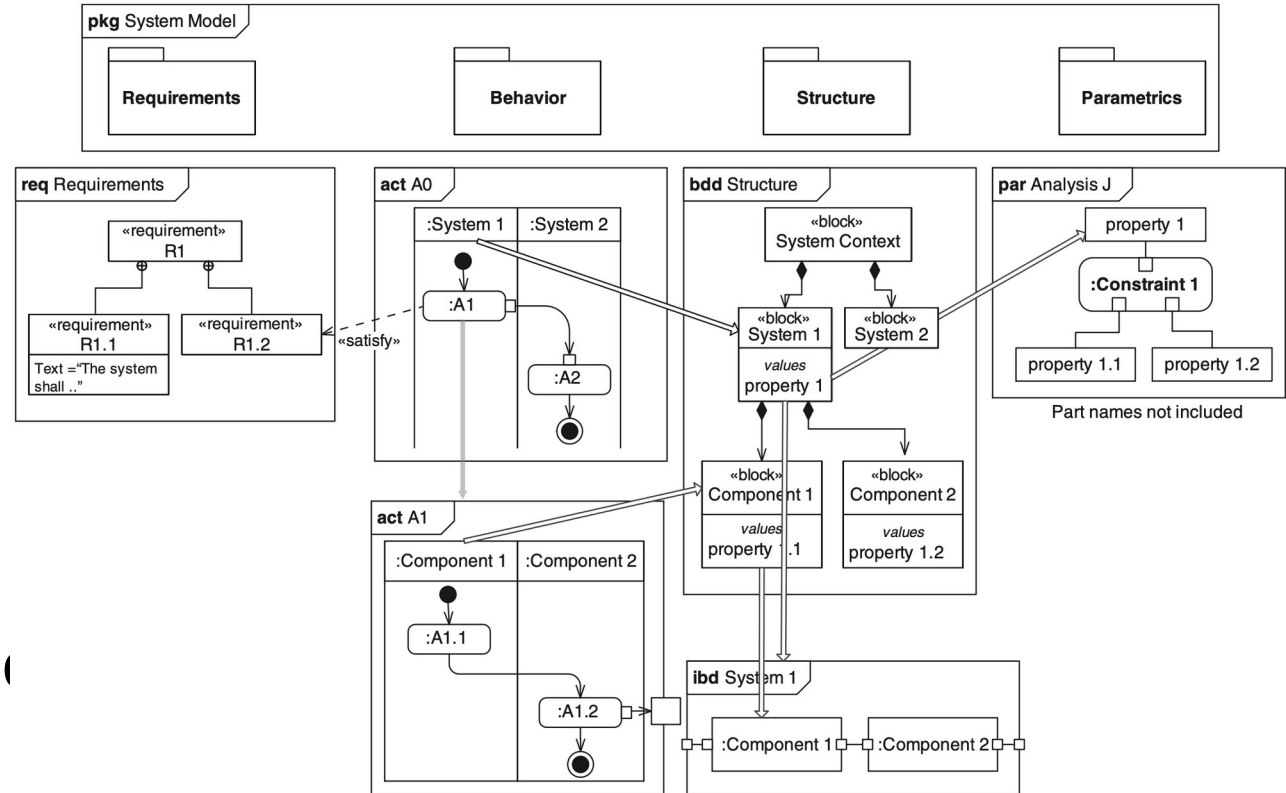
Parametric diagram
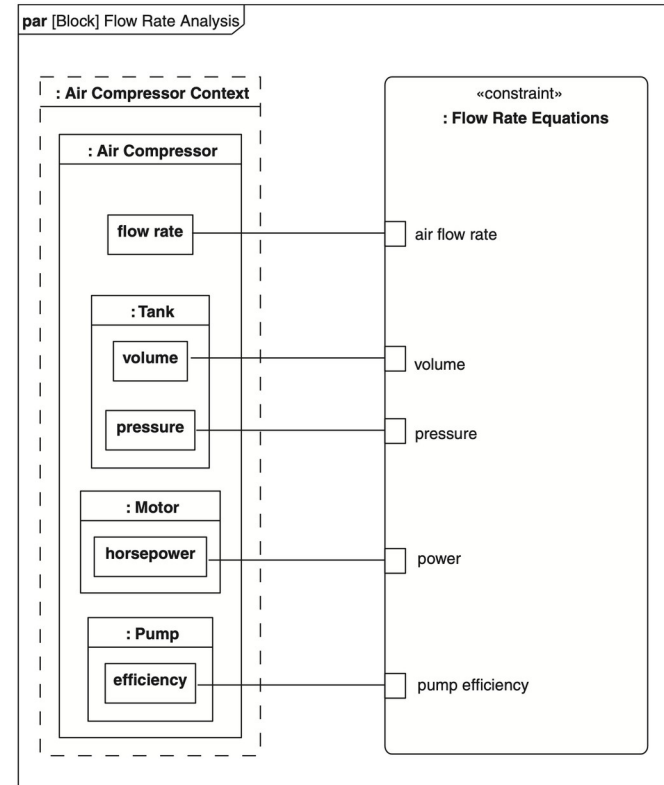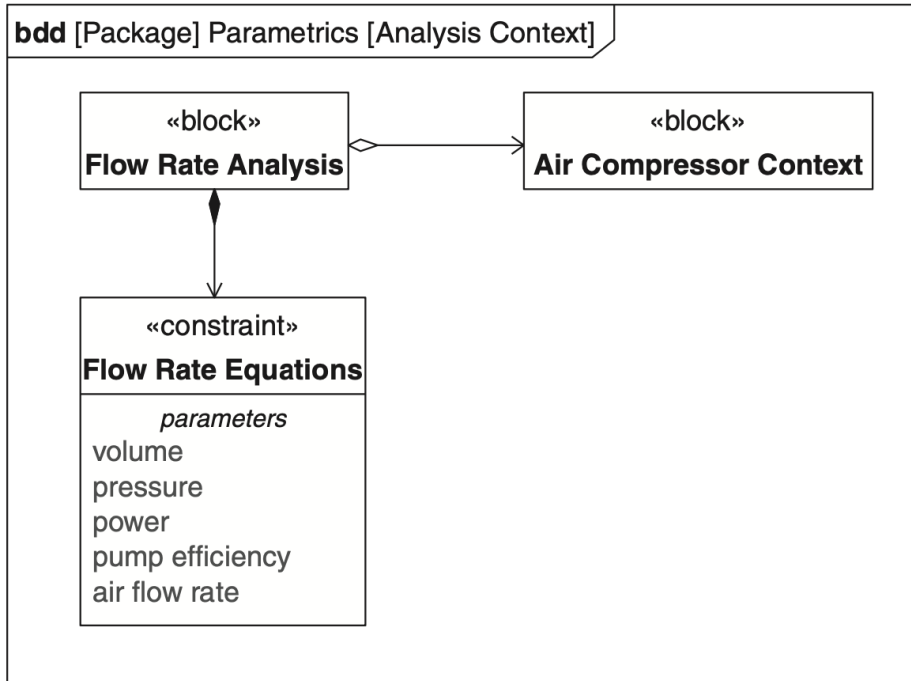
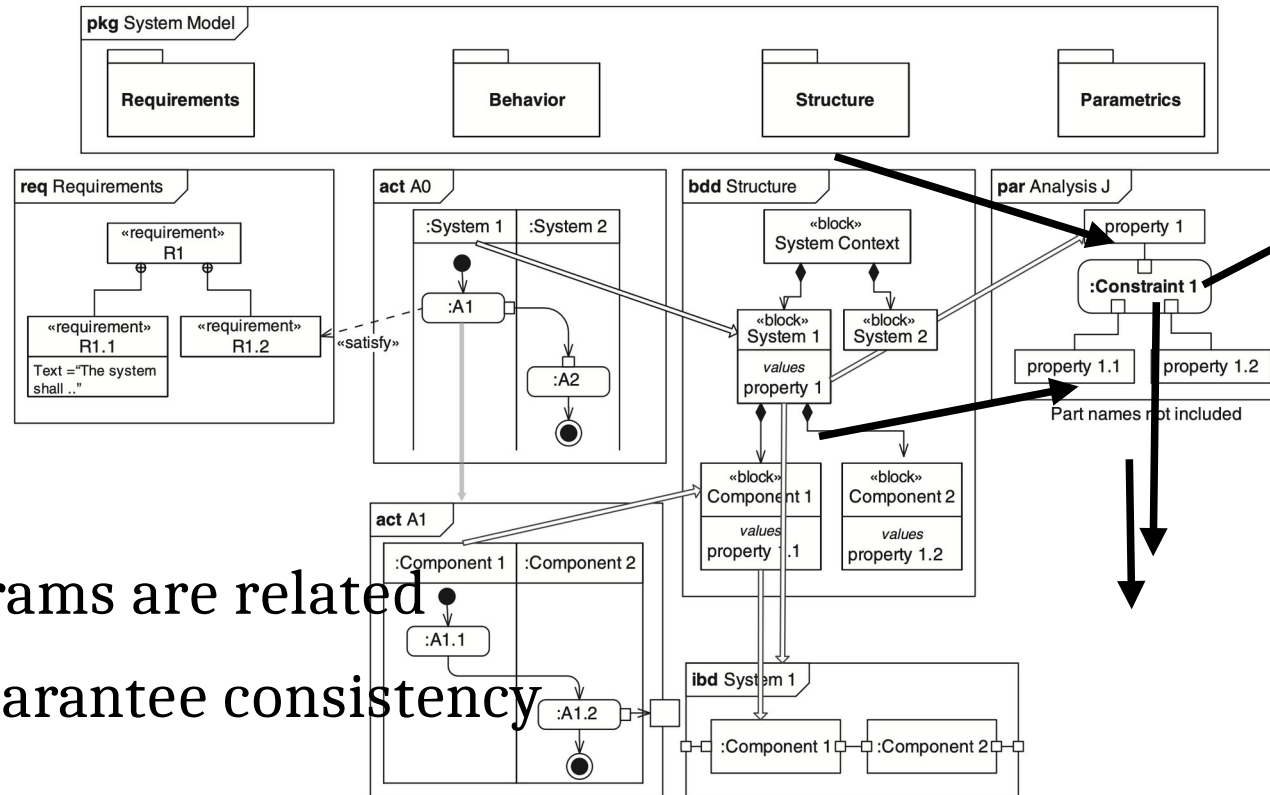# Parametric diagram
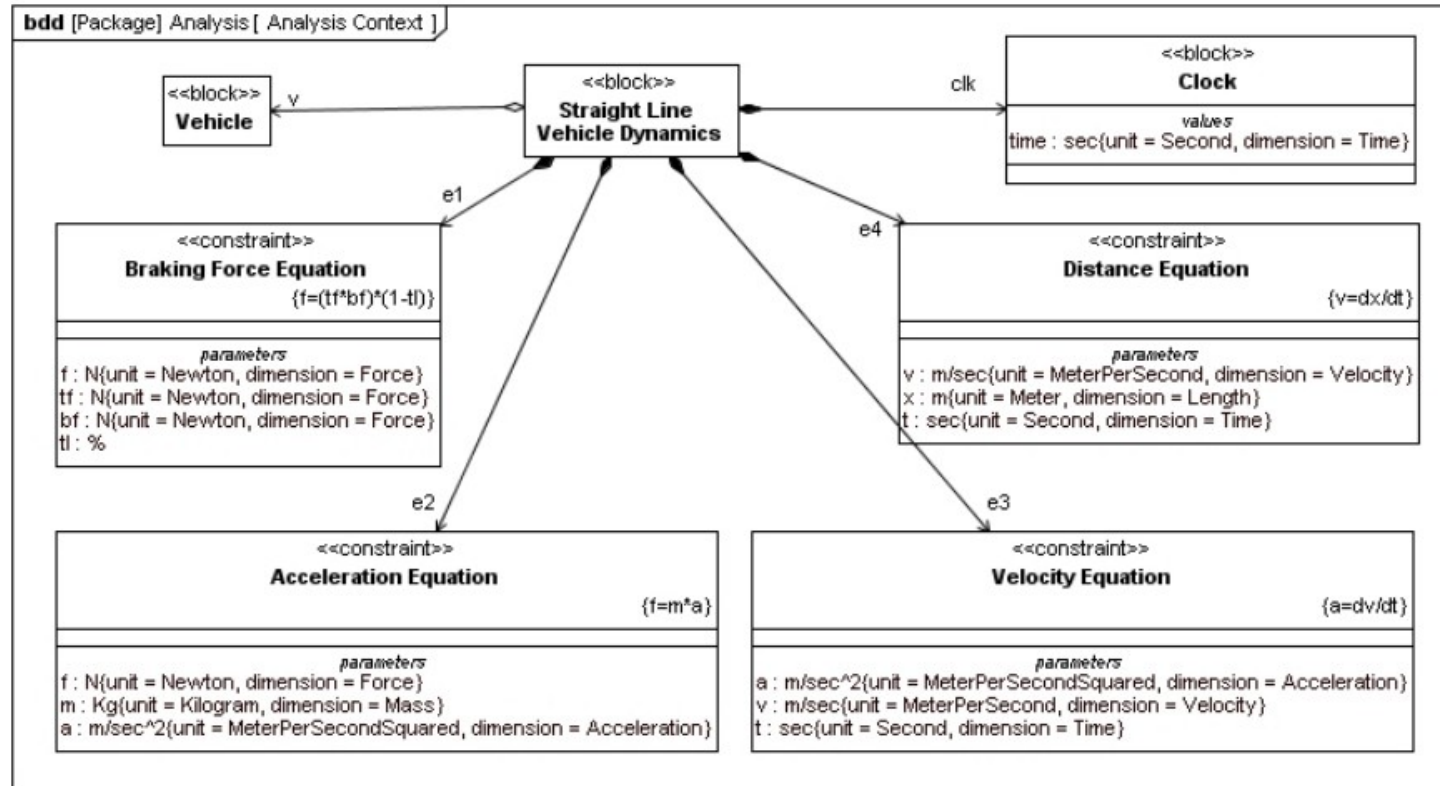
SysML-Lite

- All diagrams are

- Tools guarantee

SysML-Lite

- All diagrams are related
- Tools guarantee consistency

Next on PSIS

- Inter-Process communication
  - The Linux Programming interface
  - Oracle Solaris 11.4 Programming Interfaces Guide
  - Inter-Process Communication (IPC) in Distributed Environments: An Investigation and Performance Analysis of Some Middleware Technologies